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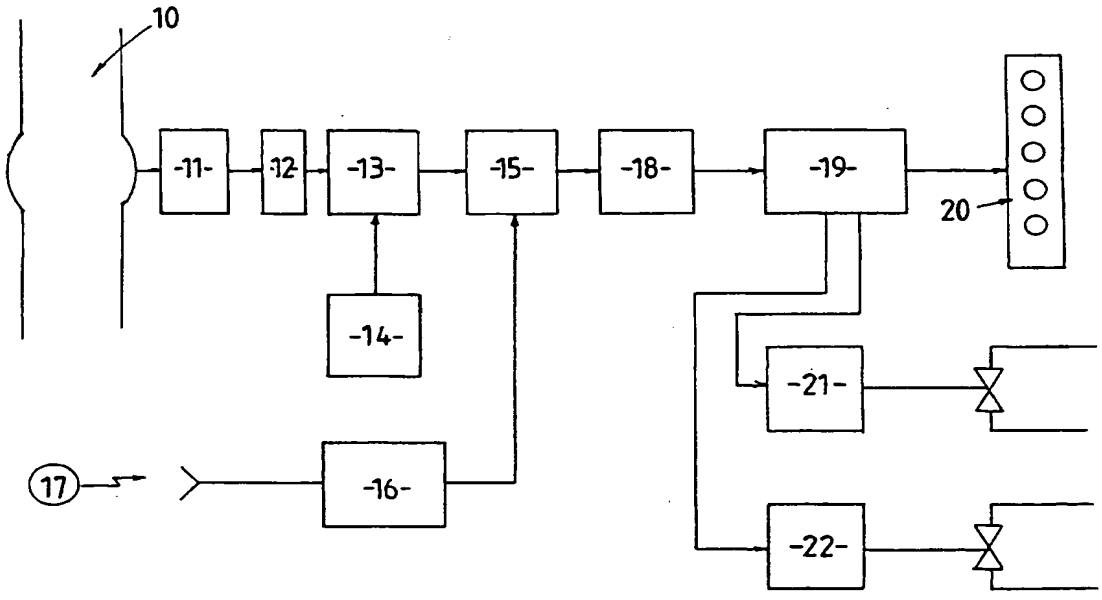
(54) Title: METHOD AND MEANS OF DETECTING ELEMENTS IN MILK



(57) Abstract: A method and means of detecting elements in milk particularly useful for detection of mastitis in milk. According to the invention milk from a milking animal is passed through a sensor having a flow passage and capacitive elements which are coupled to a reactance circuit. Voltage outputs and/or frequency modulated waveforms are derived from the reactance circuit. By analysing the waveforms and detecting change in the waveform relative to that of normal milk it is possible to detect abnormal milk e.g. milk from a cow suffering from mastitis.

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TITLE OF INVENTION

METHOD AND MEANS OF DETECTING ELEMENTS IN MILK

BACKGROUND OF THE INVENTION

The present invention relates to a method and means of mastitis detection.

The presence of mastitis in a milking animal generally represents a financial loss to the dairy farmer. Even one cow suffering from mastitis in a herd can have a real impact on the somatic cell count in milk from the herd which generally results in a reduced payment from the dairy company. It is therefore important that a dairy farmer be able to determine as quickly as possible which cow in a herd is suffering from mastitis and take the necessary remedial action.

The use of electrical conductivity of milk is being used for diagnosing mastitis with varying degrees of success. It is well known that this property is related to the ionic strength of the various solutes in the milk. However, the measurement of the conductivity of milk is affected by conductive contaminants and fouling up of the electrodes which need to be in contact with the milk in

order to detect changes in conductivity.

It is known to provide a hand-held conductivity meter into which milk can be placed in order to obtain a conductivity reading. To detect which cow in a herd is suffering from mastitis, the farmer needs, for each cow in the herd, to express each quarter separately into the conductivity meter. Not only does this result in a considerable amount of time to detect one cow in what may be a large number of cows but also it can be upsetting to the cows and represents some degree of physical danger to the farmer unless appropriate precautions are taken. While the conductivity meter can provide a means of detecting mastitis in a herd of animals, it is not a particularly practical solution for large herds.

It has also been proposed to incorporate with each milking claw in a milking parlour the electrodes of a conductivity meter. According to one proposal a sample quantity of the milk flow from a cow through the claw is automatically diverted from the flow of milk from each quarter of the cow. This sample quantity passes between conductivity probes which are wired to an instrument which indicates whether or not the milk is considered to not have an undesirable level of mastitis. However, such an arrangement not only represents a large capital outlay

to the farmer but also results in the milking claws becoming somewhat cumbersome. There is also a problem which can arise with having electrical contacts in close proximity to a hostile environment both in terms of moisture and contaminants.

It is also known to conduct a mastitis detection test on a sample of the total milk received from an animal. However, this is not a particularly successful method, especially if the milk from, say, three quarters is mastitis free as this milk will dilute the mastitis bearing milk from the other quarter and thereby prevent or make it difficult to detect the presence of mastitis.

SUMMARY OF THE INTENTION

An object of the present invention is to provide a method and means of detecting abnormal milk which is more sensitive than known conductivity methods of detection.

A further object of the present invention is to provide a method and means of detecting abnormal milk during the milking of an animal.

Broadly according to one aspect of the invention there is provided a method of detecting abnormal milk from a milking animal including the steps of:-

(a) causing milk to flow through a flow passage associated with capacitive elements coupled to a reactance circuit,

(b) deriving an output or waveform from the reactance,

(c) analysing the reactance circuit output or waveform and detecting change in the output/waveform indicating abnormal milk flowing in the flow passage.

According to a second broad aspect of the invention there is provided an abnormal milk detector including:-

(a) a flow passage,

(b) capacitive elements associated with the flow passage and coupled to a reactance circuit,

(c) reactance circuit output detection means, and

(d) analysing means to determine a rectance circuit output indicative of abnormal milk flowing in the flow passage.

Preferably the output is a voltage ouptput or waveform.

In an alternative arrangement the output is a frequency modulated output or waveform.

Preferably the capacitive elements, in the form of plates, are not in direct contact with the milk.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram of one form of the milk detector according to the present invention,

Figure 2 is a graphical representation of a voltage plot derived from the detector according to Figure 1, the plot being that resulting from testing of normal milk,

Figure 3 is similar to Figure 2 but showing the result of low level mastitis bearing milk,

Figure 4 is a basic resonance circuit with reactive components, and

Figure 5 is a further block diagram of another form of the milk detector according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention can form part of a stand alone detector or can be used by suitable adaptation or addition to an existing detector based equipment used in a milking parlour. The detector according to the present invention can therefore form, for example, apparatus used to detect the end point of milking of an animal and for the removal of teat cups at the conclusion of milking.

The detector according to the present invention is intended to detect abnormal milk during the milking of an animal and to "flag" the detection of abnormal milk to the farmer. The detector could also be used to automatically cease milking of an animal detected as producing abnormal milk by, for example, actuating an end of milking device. The detector could also be embodied in hand-held devices to provide more sensitive detection of mastitis than known hand-held versions relying on sensing of increased conductivity.

It is known to detect the amount of liquid flowing through a flow passage by providing capacitive plates associated with the flow passage, these plates effectively forming a capacitor with the dielectric being

formed by the liquid within the flow passage. Such a method of detecting the flow of milk is, for example, described in our Australian patent specification 585281.

The concentration of certain soluble and suspended constituents of milk are affected as a result of udder infection in a cow. The changing constituents of the milk in the flow sensor affects the dielectric properties. Hence the capacitance and reactance of a circuit in which an effective capacitor is formed by the capacitive plates C1 (Figure 4) in association with the fluid C2 can alter relative to the changing constituents. The basis of the present invention is the discovery that this relationship can be used to detect the presence of mastitis.

As is known, the term reactance is used to denote the opposition which an inductance or capacitor offers to the passage of alternating current.

The reactance of a circuit causes modulation of the frequency which can be converted to varying dc voltage output. The voltage output can thus be analysed as waveforms to provide different wave shapes for different ionic strengths at different frequencies. Thus, the wave shape can be used to indicate whether or not the milk

being analysed is normal or abnormal, ie the presence of bovine mastitis or sub-clinical mastitis.

According to the present invention analysis is carried out by a microprocessor and appropriate software so that any change of output relative to a set of preprogrammed curves can be sent to a display device, alarm device or similar. The deviation above a preprogrammed curve can also be used to cease milking of the animal. It has been found that the sensitivity of using a reactive circuit is higher than the conventionally used conductivity method so that the abnormal milk can be detected even if the abnormal milk is only issuing from one quarter. As a result, when the milk flow being analysed comprises abnormal milk from, say, one quarter, the abnormality is detected even if the abnormal milk is diluted by the milk from the other "good" quarters.

Referring to Figure 1, a device in accordance with one form of the invention is shown. The invention in this form is by way of example intended for incorporation into the devices disclosed in Australian patent specification 585281 and New Zealand patent specification 328943.

The invention of AU 585281 is a basic resonance circuit with reactive components (Figure 4), ie C1 (the walls of

the sensor), C2, and with R, L the ionic solution in the sensor 10.

Milk flow from the animal being milked therefore passes through sensor 10 which constitutes capacitor C1 of the above indicated resonance circuit. In Figure 4 the values of C2, L and R vary with the ionic properties of the milk and the frequency of the oscillator. The output from the sensor 10 passes to an oscillator 11 which via divider 12 is applied to the phase comparator 13. The reference oscillator 14 is coupled to the phase comparator 13 which generates a dc voltage (Figure 2).

Connected to the phase comparator is a dc conditioning circuit 15. As will hereinafter be described, this conditioning circuit 15 is coupled to the analogue/digital converter 18 which in turn applies an output to microprocessor 19. The resulting waveform shown in Figures 2 and 3 is an example of dc conditioning at one of many possible oscillator base frequencies.

The milk flow through the sensor 10 is a pulsed milk flow as a consequence of the pulsator action in the milking plant. Consequently, the device senses a voltage output which varies as the pulsed milk flow through the sensor 10 varies. This is, for example, represented in dc form

by Figure 2 which is a wave form resulting from a fixed rate flow of milk which is considered to be "normal". When compared with the wave form of Figure 3, however, which is derived from milk which originates from a cow having sub-clinical mastitis, it will be seen that the wave form is of less amplitude as a consequence of less rate of change of the output voltage between pulses of milk flow through the milk sensor 10. Therefore, the difference between the maximum and minimum voltages over a wave cycle is greater for milk which is considered to be normal when compared with milk considered to be abnormal, ie from a cow having a sub-clinical infection.

The microprocessor 19 can therefore be programmed to detect a wave form from the milk sample as a difference between maximum and minimum voltage which indicates that the milk is abnormal. The microprocessor 19 can then, for example, apply a signal to a display 20 which provides a visual indication to the farmer that the milk is abnormal. The voltage levels the microprocessor requires to calculate abnormal milk can be transmitted via receiver 16 from optical data transmitter 17.

With the invention of AU 585281 the display 20 can be formed by the milk flow display forming part of the apparatus. Equally, however, the microprocessor 19 could

activate a warning signal of an audible nature or a combination of audible and visual indicators.

When incorporated in the device of AU 585281, the microprocessor 19 being coupled to control valves 21 and 22 can cause a shutdown of the milk line and vacuum to the teat cups to thereby cause the teat cups to be removed from the animal. This provides the benefit of automatically ensuring that milk from the infected cow does not flow into the milk holding vat.

At the farmer's option the mastitis detector apparatus can remain operative for every milking or could be used to detect which cow or cows in the herd is suffering from mastitis after the farmer has received an adverse cell count from the dairy company. Via the optical data receiver 16, the farmer can from his/her remote (hand held) transmitter 17 adjust the level at which the microprocessor 19 will detect what constitutes abnormal milk.

Therefore, the degree of sensitivity or threshold at which the farmer wishes to detect whether a cow is producing abnormal milk can be readily adjusted. The apparatus therefore enables the farmer to automatically detect which cow or cows in the herd are suffering from

mastitis and then take remedial action. Generally, once the animal is identified the farmer would test the animal to find out which quarter(s) is/are affected.

It will be appreciated by those skilled in the art that the microprocessor can be programmed in a number of different ways to suit the desired end result. For example, the microprocessor could be programmed to only sample part of the entire milking procedure for each animal. It would therefore average each reading over that portion of the reading.

The waveforms from the reactance circuit described herein can be digitised so that base points and numbers can be stored, multiplied and divided to create register averages. Individual cows will be compared to a herd average register of their data and discarded if they are outside a certain threshold. The microprocessor could average over the entire milking procedure for each animal. In general, however, the microprocessor would at least be programmed to ignore a certain time span at any time of milking so as to ensure that accurate detection reading is obtained. For example, it is preferable to ignore the beginning part of the milking cycle in case any abnormal milk from a preceding cow remains in the detector and which may therefore contaminate an accurate

reading for the next cow being milked at that particular milking station.

The present invention thus provides a method and means for reactance detection of bovine mastitis or sub-clinical mastitis or abnormal milk. The method and means enables detection to be carried out "in line" while the cow milks using normal milking equipment. The threshold levels for detection can be readily adjusted and can therefore be programmed using infrared methods as described, for example, in NZ 328943.

According to the circuit of another form of the invention as shown in Figure 5 the modulated frequency output derived from the sensor 10 is analysed directly. As shown a microprocessor counter/timer 19a replaces reference oscillator 14 and conditioning circuit 15. The microprocessor 19a is thus connected direct to the divider 12.

This form of the invention does not need to produce dc output waveforms as frequency modulated waveforms do not have a dc dimension. It will be appreciated by those skilled in the art that suitable software would be used to accomplish waveform analysis.

As with the previously described embodiment the device senses a frequency modulated output which varies as the pulsed milk flow varies through the sensor 10.

Microprocessor 19a is programmed to detect differences in the modulated waveform from the milk sample that is normal or abnormal. The microprocessor 19a then, as with the previous embodiment, applies a signal to a display 20 or some audible alarm arrangement. The programme the microprocessor requires to calculate abnormal milk can be transmitted by receiver 16 from optical data transmitter 17.

According to the present invention, animals are monitored "be exception". This means that only animals above a set threshold as established by the farmer will be flagged as producing abnormal milk. Once "flagged" the detector can be used to set alarms (both visual and audible), stop the milking process, draft the animal or separate the animal but only by exception.

Reactance monitoring, according to the present invention, by exception and cow side quarter testing using conductivity provides early detection of an infection well before the immune system somatic cell count response

by the cow. Early detection can thus be used to reduce the severity and cost of the infection.

The present invention according to its preferred form has concentrated on mastitis detection. At different base frequencies, other elements present in milk will produce other waveforms, e.g. amplitudes, rise and fall times or modulations caused by variation in impedance. Microprocessors now available can be used to carry out real time simultaneous analysis of the waveform as fluid flows through the sensor.

CLAIMS

1. A method of detecting abnormal milk from a milking animal including the steps of causing milk to flow through a flow passage associated with capacitive elements coupled to a reactance circuit, deriving an output or waveform from the reactance circuit, analysing the reactance circuit output or waveform and detecting change in the output/waveform indicating abnormal milk flowing in the flow passage.

2. The method according to claim 1 wherein the capacitive elements are not bought in direct contact with the milk.

3. The method according to claim 1 or 2 wherein the reactance circuit output or waveform is compared with one or more predetermined output or waveform.

4. The method according to claim 1 wherein the reactance circuit output detected is a voltage output or waveform.

5. The method according to claim 1 wherein the reactance circuit output or waveform is frequency modulated.

6. The method according to any of one the preceding claims wherein a signal is produced upon detecting a change in the output/waveform indicating abnormal milk flow said signal being used to activate a warning device or enable a display to indicatean abnormal reading.

7. The method according to claim 6 wherein the signal is applied to an end of milking device to cease milking of the animal upon detection of the abnormal reading.

8. The method according to any claims 1 to 6 wherein the method is carried out during a milking procedure.

9. The method according to claim 8 wherein the method is carried out during only part of the entire milking procedure.

10. An abnormal milk detector including a sensor (10) with flow passage, capacitive elements (C1)

associated with the flow passage and coupled to a reactance circuit (C2, R, L) reactance circuit output detection means (11, 12) and analysing means (13,14) to detect a reactance circuit output indicative of abnormal milk flowing in the flow passage of sensor (10).

11. The detector according to claim 10 further including microprocessor means (19) programmed to detect a difference between maximum and minimum voltage to indicate abnormal milk flowing through said flow passage.

12. The detector according to claim 10 includes microprocessor (19a) means programmed to analyse a frequency modulated output or waveform from the reactance circuit.

13. The detector according to claim 11 or 12 wherein the microprocessor (19, 19a) is coupled to indicator means (20) to indicate said abnormal milk.

14. The detector according to claim 11 or 12 wherein the indicator (20) includes visual and/or audible indicating means.

15. The detector according to claim 11 wherein an output signal from the flow sensor incorporating said flow passage and capacitive elements is applied to an oscillator (11) which is coupled via a divider (12) to a phase comparator (13) connected to a reference oscillator (14).

16. The detector according to claim 12 wherein a dc output from said comparator (13) is applied to a dc conditioning circuit (15) which is coupled to an analogue/digital converter (18), said converter being coupled to said microprocessor (19).

17. The detector according to claim 12 wherein an output from a flow sensor (10) incorporating said flow passage and capacitive elements is applied to a progammable microprocessor (19a).

18. The detector according to claim 17 wherein the microprocessor (19a) with an inbuilt counter has memory means to store samples of frequency, these samples being analysed with software to datalog the waveform.

18. The detector according to any one of claims 11 to 18 further including remote control means (16) operable to adjust the level or parameter at which the microprocessor (19, 19a) will detect what constitutes abnormal milk.

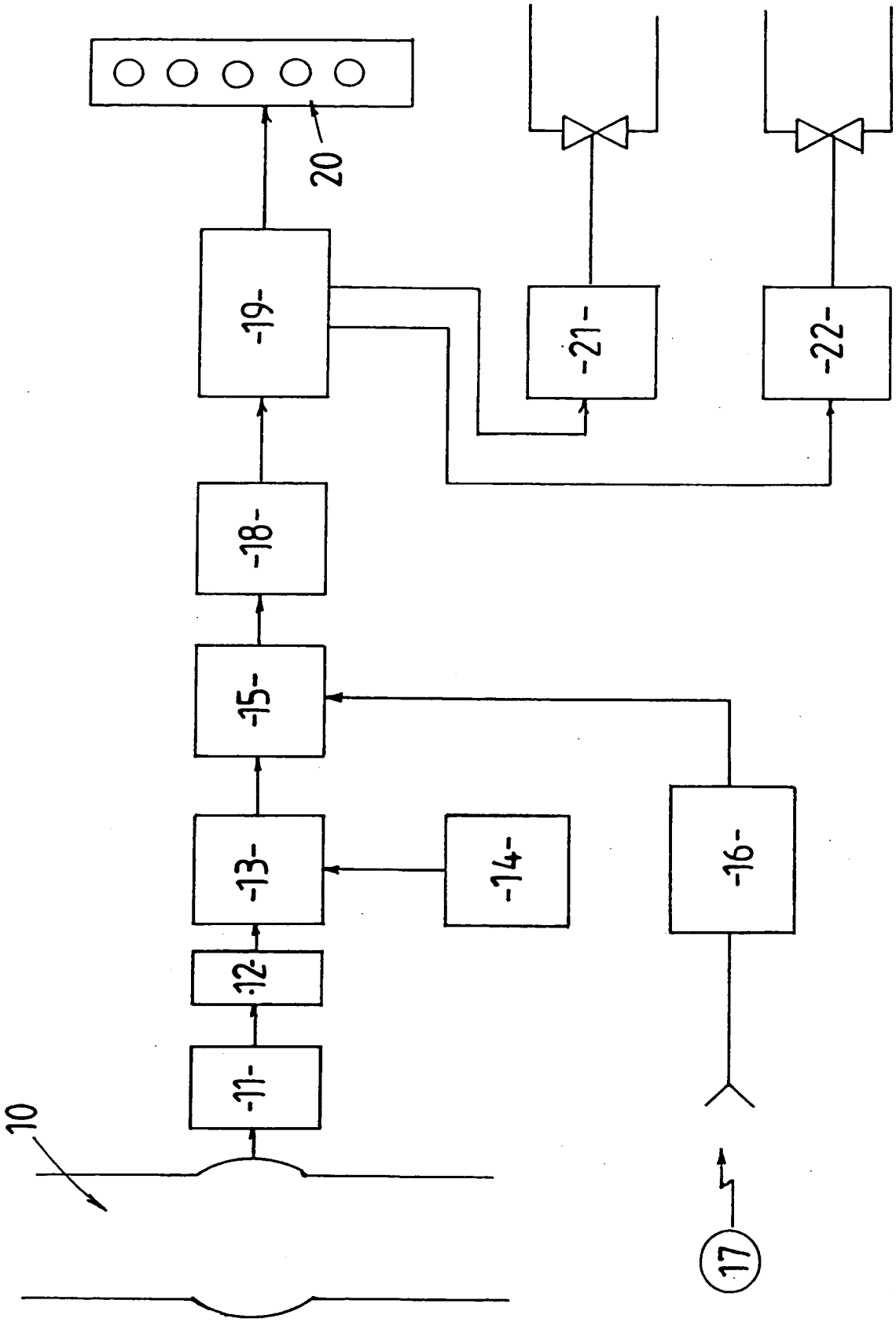
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FIG. 2.

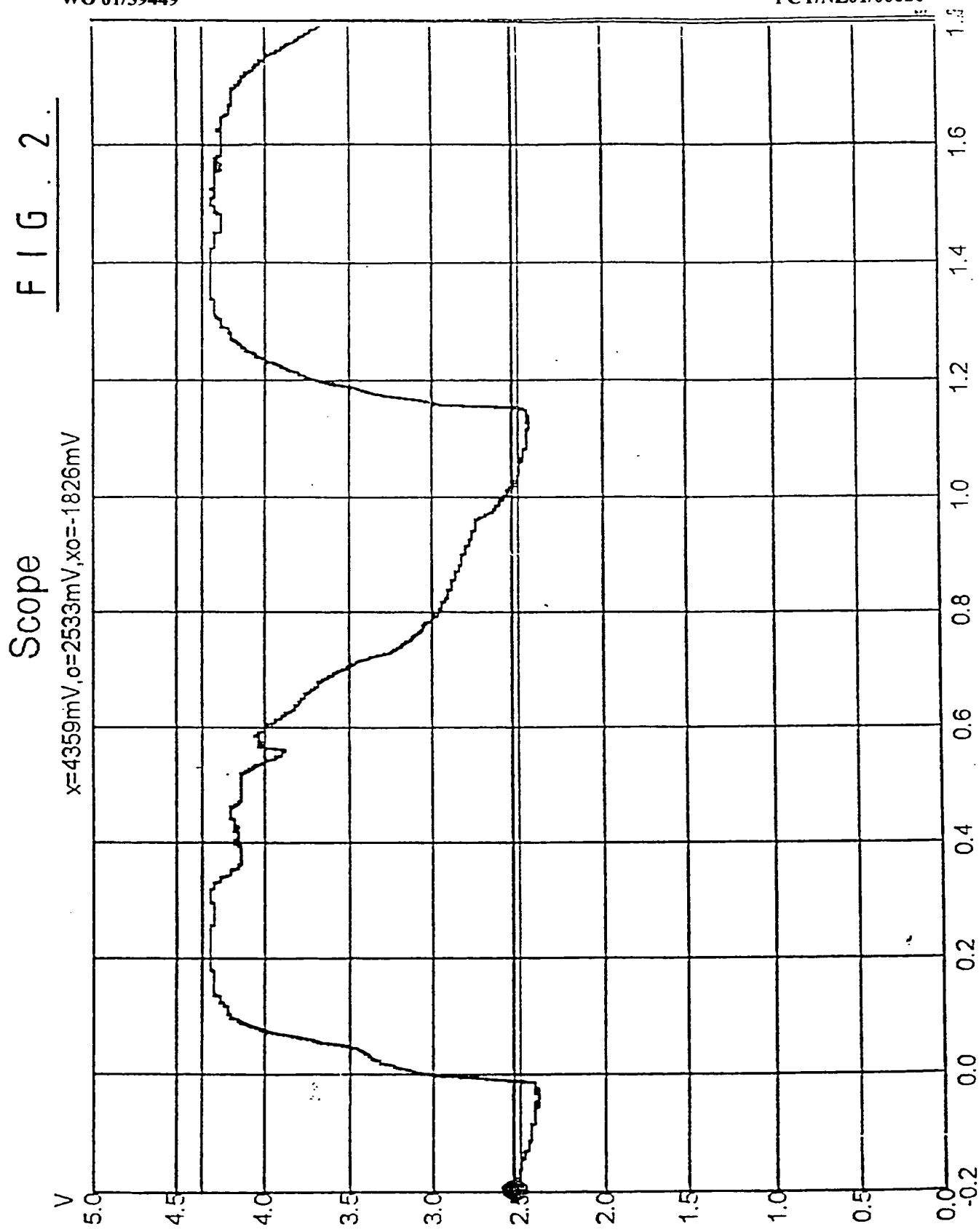
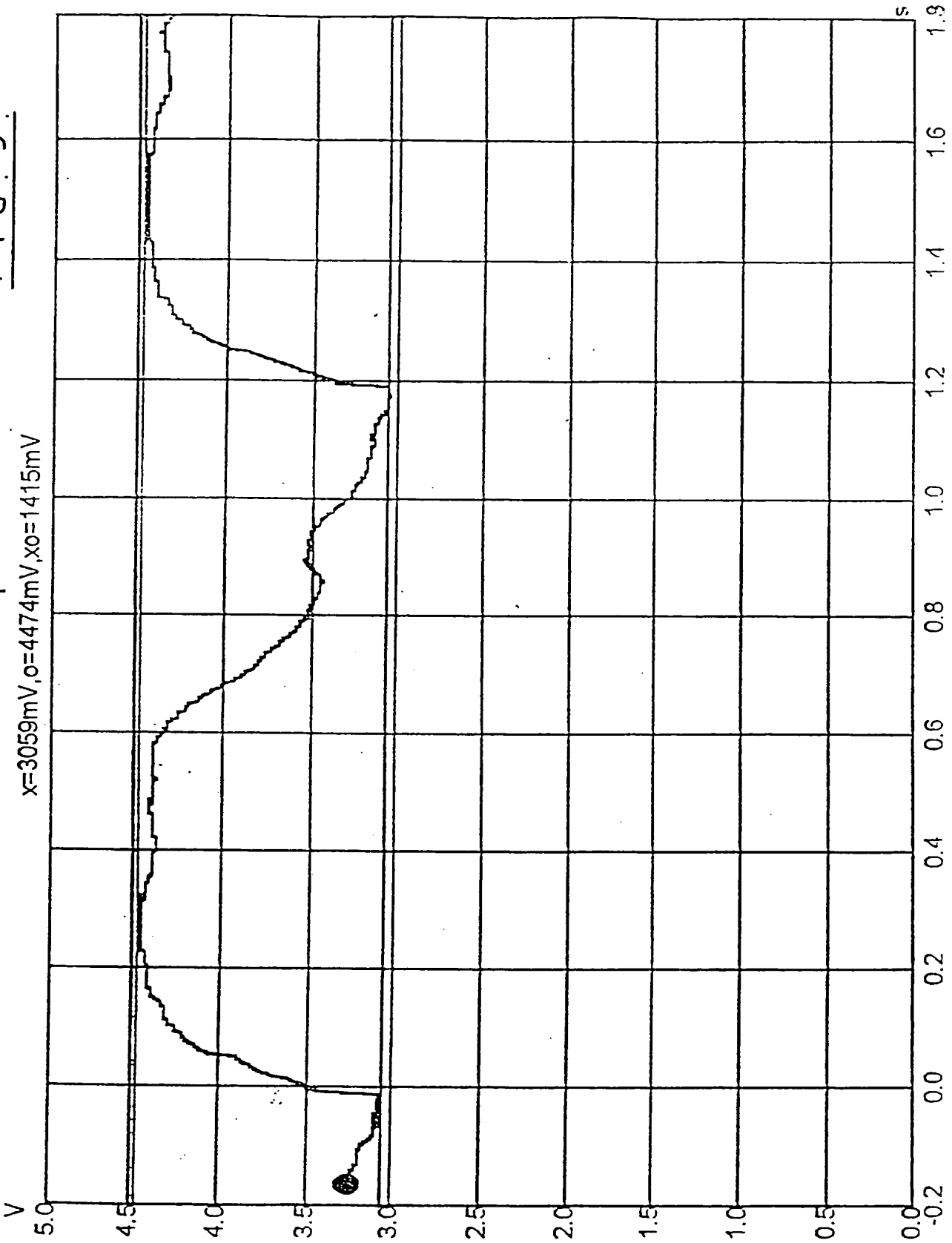


FIG. 3.



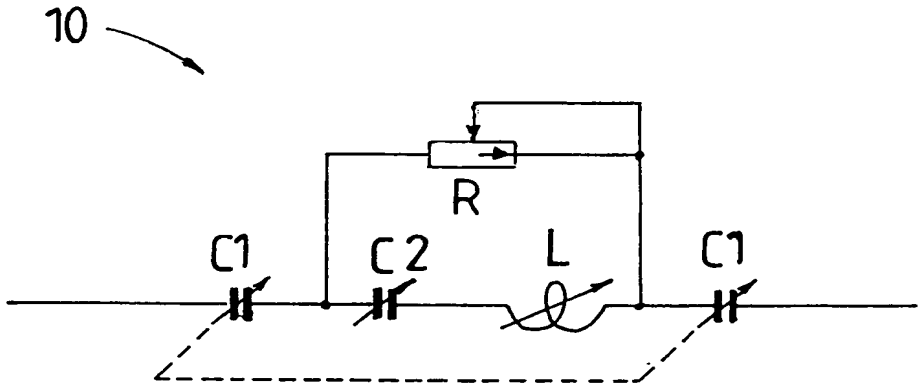


FIG. 4.

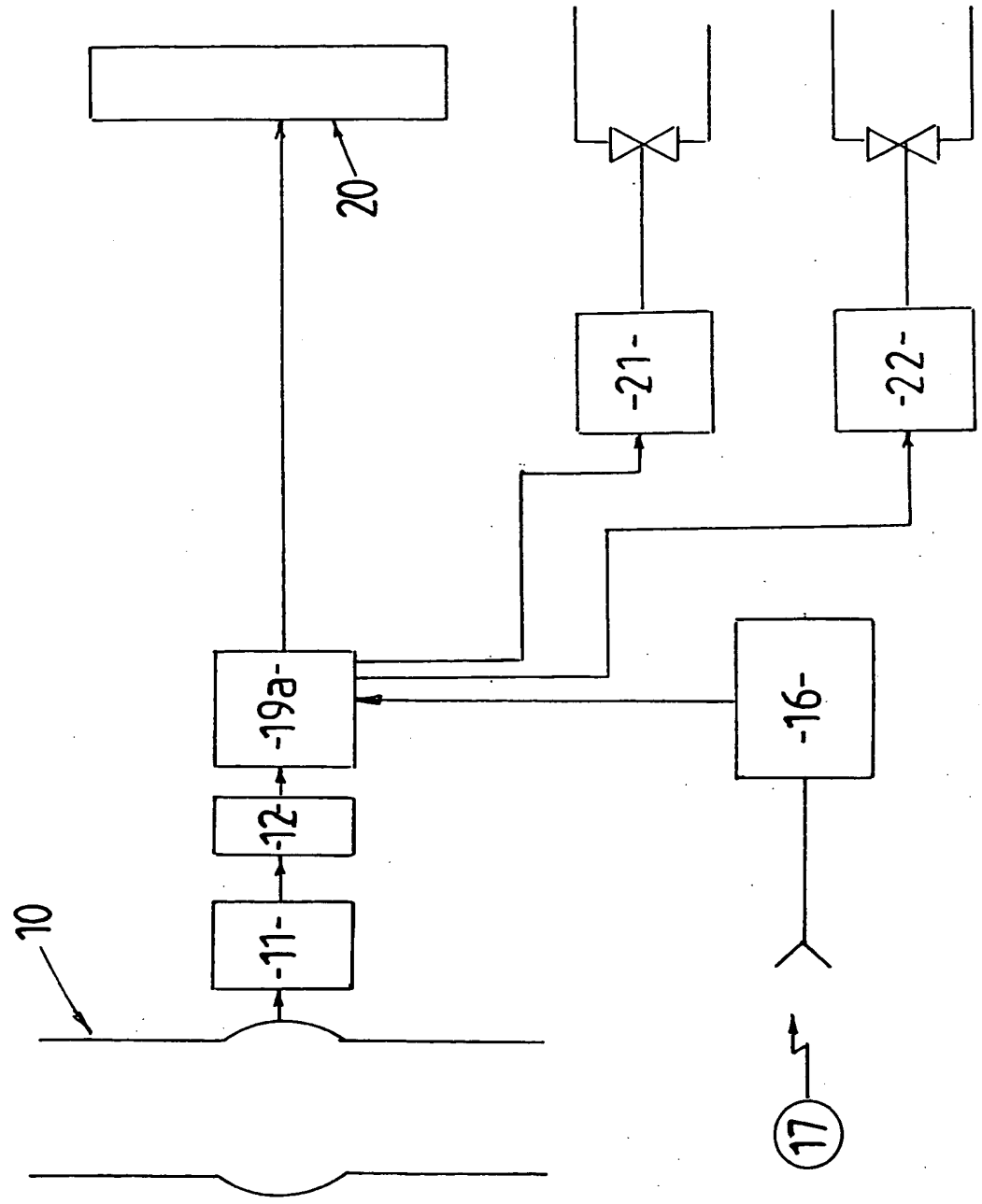


FIG. 5.

INTERNATIONAL SEARCH REPORT

Inter ›nal Application No
PCT/NZ 01/00020

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01N33/50 G01N33/04 G01N33/06 A01J5/013

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01N A01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropnate, of the relevant passages	Relevant to claim No.
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A	EP 0 182 654 A (ALLFLEX INT) 28 May 1986 (1986-05-28) cited in the application page 1 -page 7; claims 1-3 ---	1-19
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
27 June 2001	19/07/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Joyce, D

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INTERNATIONAL SEARCH REPORT

Inter nal Application No
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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

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